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THE INFLUENCE OF THE MELTING POINT OF THE BARREL MATERIAL ON EROSION. PROJECT RB 152

Firing with Molybdenum Barrels

A number of theories have been advanced* in explanation of the erosion of guns but the one receiving the most credence at present is the "gas wiping" theory according to which the metal of the interface of the bore melts and is removed by the rapid flow of the very hot gas of the propellent powder**. The amount of metal wiped off in this fashion should depend:

(1) On the nature of the powder, the caliber and the ballistics of the cannon (which determines the weight of charge, the temperature of the gas, the speed of the gaseous current and the interval during which active erosion persists).

(2) On the physical properties of the metal e.g., the melting point, the specific heat, the latent heat of fusion, the thermal conductivity and the characteristics of the surface of the metal influencing the speed of transmission of the heat of the gas to the metal.

In addition, erosion may also be produced by mechanical abrasion of the projectile on the bore.

During the war, Steinmetz suggested that if guns were lined with tungsten, they would last indefinitely, since

* For a short concise summary of the various theories with special application to machine gun barrels, see "Erosion in Machine Gun Barrels" by J. C. Gray - Army Ordnance of July-August, 1934.

** For a detailed study of this theory see article entitled "L'Erosion des Canons" by Mm. Greaves, Abram and Rees, of Woolwich in Memorial de L'Artillerie Francaise of 1930.

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tungsten has a melting point of about 3200° C while powder gas has a temperature of about 2300° C. This suggestion was hardly practicable at the time because of the expense of tungsten and the difficulty of machining. However, Mr. Kent, after consulting with Major P. L. Alger and other engineers of the General Electric Company, recently proposed that a liner be constructed of molybdenum because this metal has a melting point of 2600° C and can be machined.

Since difficulty in machining was expected because of the hardness and heterogeneity of the metal, an attempt was first made to fabricate a 6" length molybdenum liner having an outer diameter of .600". The barrel, drilled to .590" inside diameter, was shrunk over the molybdenum. The barrel blank was then rifled and chambered in the usual manner and the portion ahead of the insert was reamed over size to .312" and left smooth. It should be mentioned here that the machining of the liner proved exceedingly difficult and left the bore and chamber rough and chipped.

After several rounds, firing had to be discontinued because the molybdenum insert had been pushed back by the pressure of the gases on its forward end. The insert was brazed to the steel at the breech end and several more rounds fired but firing had to be stopped again for the same reason. It was necessary, in order to continue firing, to cut off the barrel at about 1/2" in front of the liner, counterboring the hole in this 1/2" section to about 1/2" diameter. This reduced the pressure on the forward end of the insert; the 1/2" of steel left was necessary to maintain the bearing surface of the barrel on the receiver.

With these alterations, the gun functioned perfectly, firing at a maximum rate of about 900 rds/min. The rate of fire maintained in the test was such as to maintain the temperature of the one thermocouple placed on the barrel at 300° C. In all 4649 rounds were fired before discontinuing the test because of the fact that the lands appeared to be very much worn.

In order to have a basis of comparison a standard M2 barrel was modified in the same manner and fired the same number of rounds maintaining the same temperature. Both guns were star gauged several times during the test.

Plots at the end of the report show the measurements.

The star gauge measurements of the molybdenum rifle are not complete because the condition of the grooves prevented the insertion of the star gauge guides. However, it is evident that the grooves of the molybdenum insert after 4649 rounds show no sign of erosion where measurements could be made, while the grooves of the cut-off standard barrel show abnormal erosion. The lands of the molybdenum rifle show an increase in diameter but not as great an increase as those of the standard barrel.

After the firings were completed both barrels were sectionalized axially and photographs, prints of which are attached, were taken of a portion including part of the chamber, the forcing cone and part of the rifled section. Examination of print No. 1, that of the standard steel barrel, shows the customary heat cracks just in front of the chamber. Print No. 2 shows the corresponding portion for the molybdenum barrel; as may be seen, there are no heat cracks in front of the chamber but there are some circumferential marks discernible near the end of the cartridge case. These are evidently the tool marks formed in the machining of the gun. They may be considered as strong evidence that little or no erosion occurred in this section of the molybdenum barrel.

According to the gas wiping theory, erosion of the grooves of small arms is due entirely to the melting and wiping of the surface of the grooves by the hot powder gases while the erosion of the lands is due also to mechanical abrasion by the projectile. If the melting point of the interface is raised to a temperature higher than that of the gases then no melting should occur and the erosion should effect the lands exclusively, with all of the wear due to abrasion. It is probably true that the effect of abrasion is greater on the molybdenum than on the steel because the metal is not homogeneous in structure. Molybdenum cannot be worked very easily and according to the manufacturer, the center of the rod received nothing but a "squeeze"; as a result, the interface may contain hidden cracks which augment its sensitivity to frictional abrasion.

SUMMARY

The results obtained in this test support the gas wiping theory in that no erosion occurred in the region of the forcing cone or the grooves in the molybdenum barrel. The erosion of the lands is due to the mechanical abrasion of the projectile and abrasion, in the case of molybdenum, at least, is of great importance.

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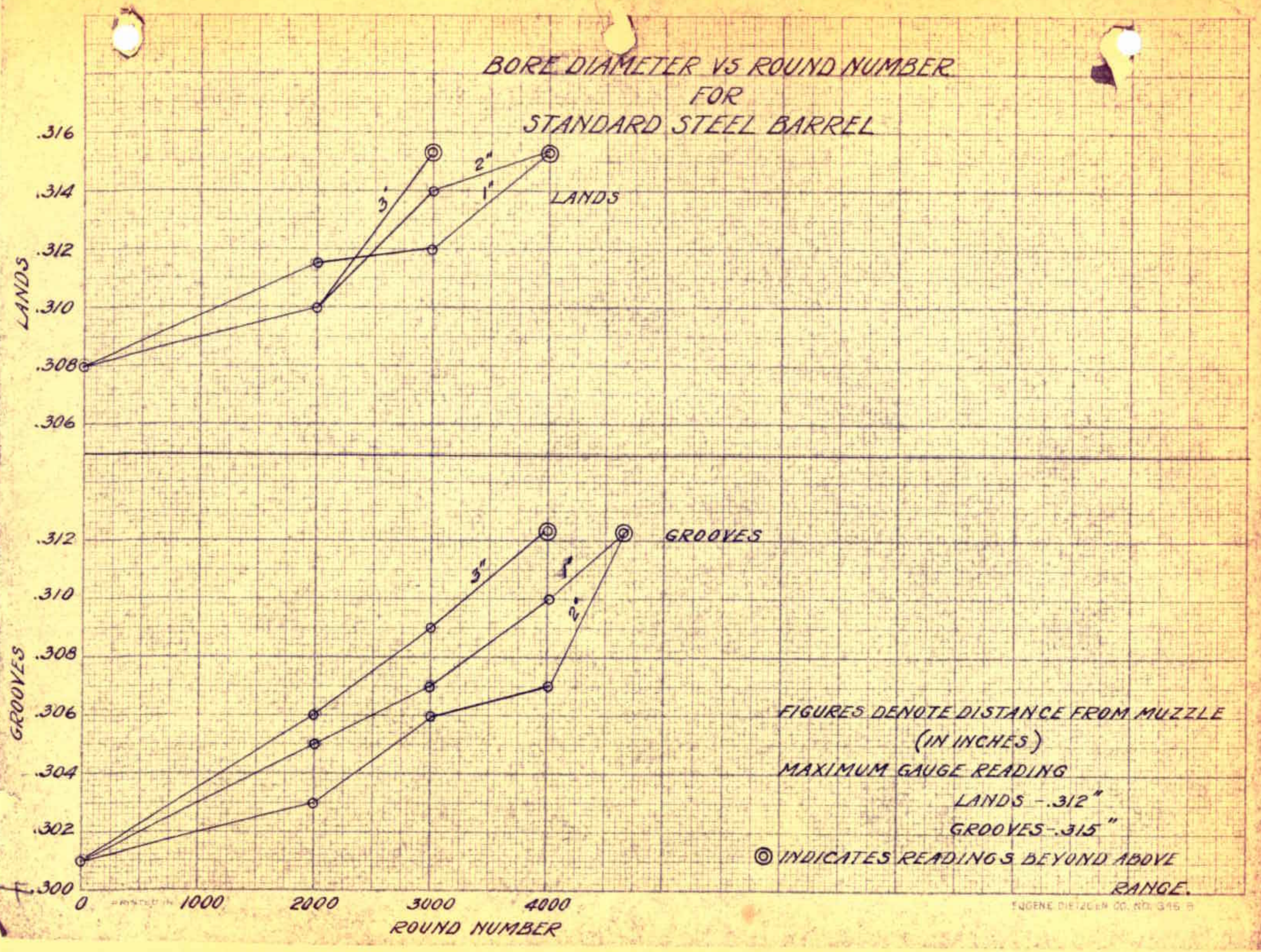
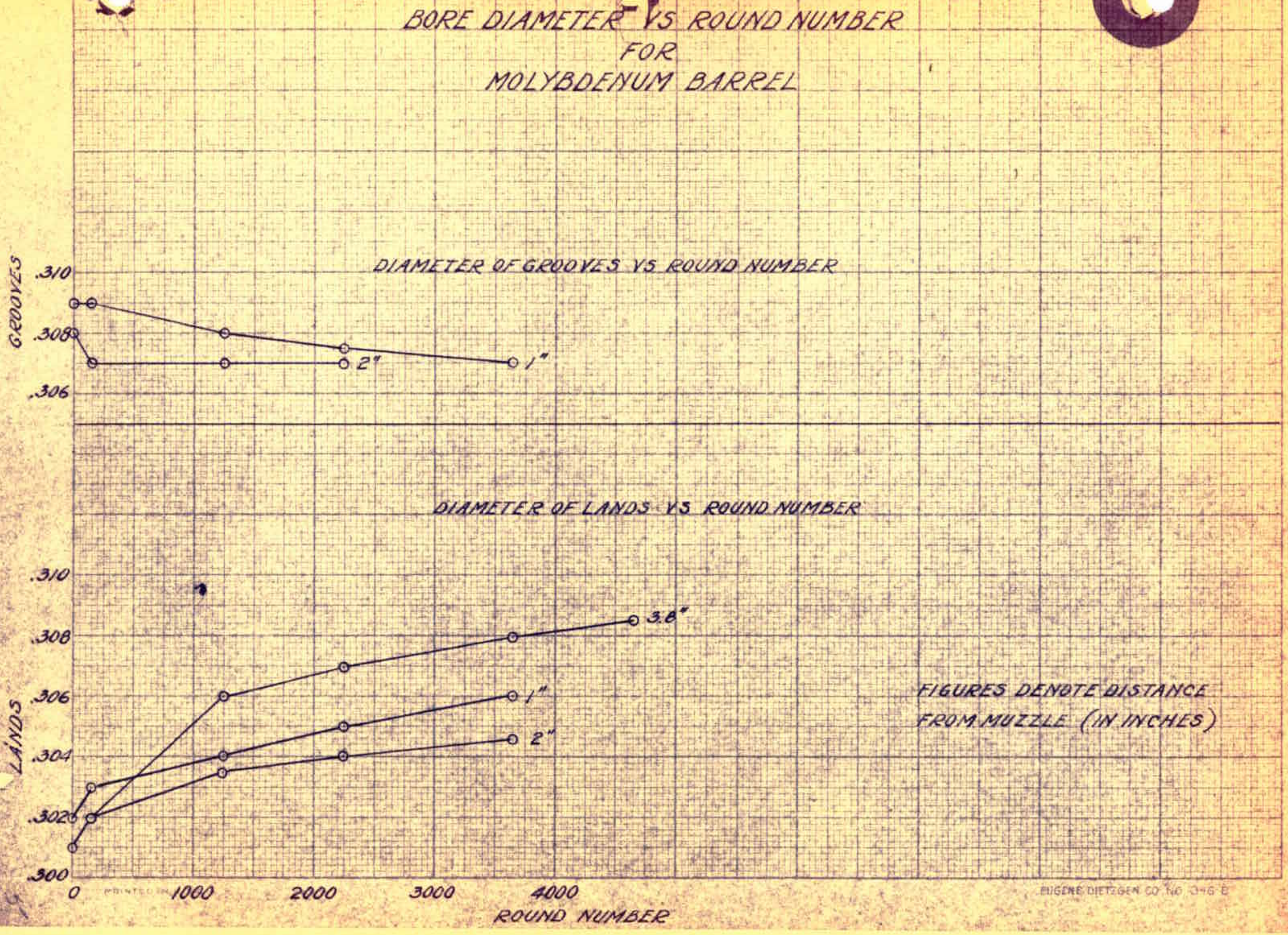
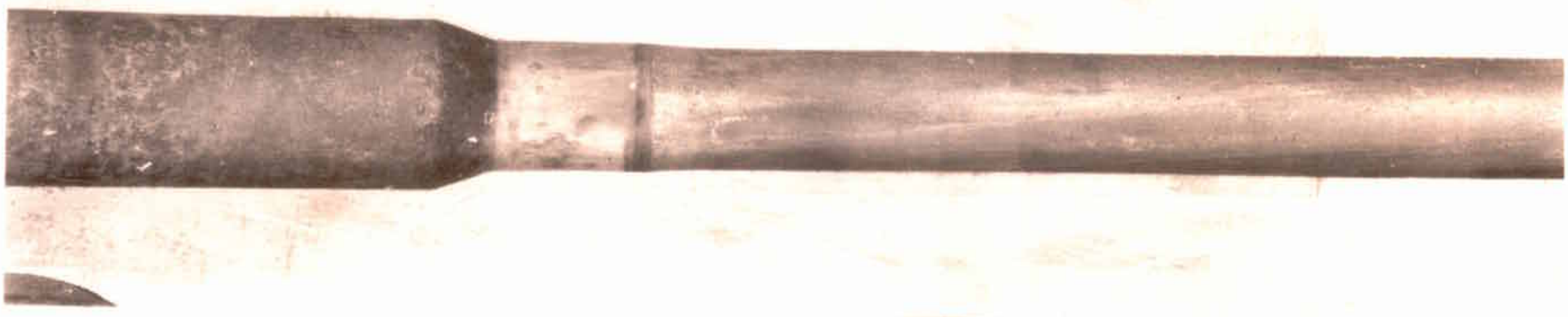

BORE DIAMETER VS ROUND NUMBER
FOR
STANDARD STEEL BARREL
LANDS
.316
.314
.312
.310
.308
.306
3"
2"
1"
LANDS
GROOVES
.312
.310
.308
.306
.304
.302
.300
3"
1"
2"
GROOVES
0
1000
2000
3000
4000
ROUND NUMBER
FIGURES DENOTE DISTANCE FROM MUZZLE
(IN INCHES)
MAXIMUM GAUGE READING
LANDS -.312"
GROOVES-.315"
◎ INDICATES READINGS BEYOND ABOVE RANGE.
EUGENE DIETZGEN CO. NO. 346 B



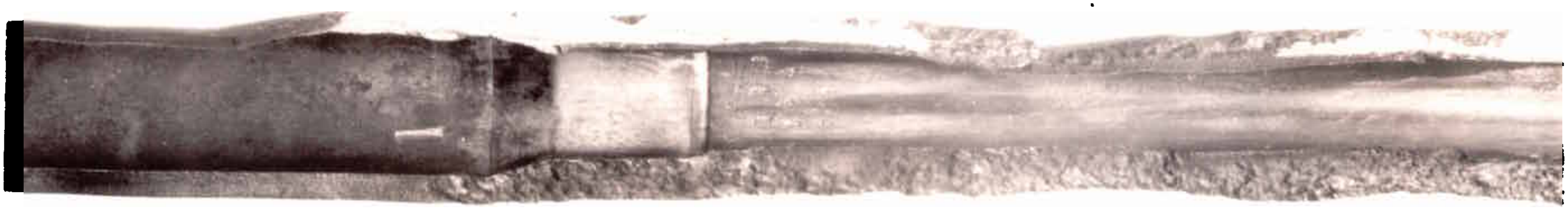
BORE DIAMETER VS ROUND NUMBER
FOR
MOLYBDENUM BARREL
DIAMETER OF GROOVES VS ROUND NUMBER
GROOVES
.310
.308
.306
2"
1"
DIAMETER OF LANDS VS ROUND NUMBER
LANDS
.310
.308
.306
.304
.302
.300
3.8"
1"
2"
FIGURES DENOTE DISTANCE
FROM MUZZLE (IN INCHES)
0
1000
2000
3000
4000
ROUND NUMBER
EUGENE DIETZGEN CO. NO. 346 B

PRINT NO. 1
CAL. .30 STEEL BARREL.



ORDNANCE DEPARTMENT. A. P. G.
39551 - 2-16-40.
Caliber .30 Steel Barrel.

PRINT NO. 2
CAL. .30 MOLYBDENUM LINER.



ORDNANCE DEPARTMENT. A. P. G.
39552 - 2-16-40.
Caliber .30 Molybdenum Liner.